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by

Hiren Sarkar

The Division of Agricultural Economics
Office of the Under Secretary of State for Agriculture
Ministry of Agriculture and Cooperatives
Royal Thai Government, Bangkok, Thailand

in cooperation with

The Center for Agricultural and Rural Development
Iowa State University, Ames, Iowa 50011

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SUMMARY

Computer simulation provides a useful tool to investigate alternative economic scenarios. In the present study, an attempt has been made to simulate a rice trade model with special reference to Thailand. An aggregative model is used in which the world is divided into two groups: (a) exporters and (b) importers. It is assumed that the importing group operates under contraints of resource restrictions and population pressure. Hence, there is very little opportunity for production adjustment. The exporting group is considered to have considerable surplus production capacity and is price responsive. Thailand is treated as a member of the exporting group, and a submodel for Thailand has been constructed with linkages to the main model. A set of structural equations is estimated and used to construct a recursive simulation model. Short period predictions of variables such as trade and export prices are made. A simple stochastic version of the simulation model also is formulated and used for prediction purposes. For Thailand, a number of policies are analyzed within the framework of a simulation experiment. A package program of the simulation method also is provided for convenience.

INTRODUCTION

Rice is the most important agricultural commodity in Thailand. Rice has two important uses for Thailand: (a) domestically, it is the main staple food and (b) it is the main agricultural export. Revenue from rice exports provides the major share of Thai export earnings. Although Thailand accounts for only 5 percent of world rice production, it is responsible for nearly 25 percent of the total international rice trade. Large exports are possible because of the surplus of production over domestic use. Thailand must evolve rational policies to maintain this surplus consistent with the world demand.

A general objective of this study is to build a rice trade model for Thailand. The trade model has three major subsectors: (a) domestic production and use, (b) foreign demand, and (c) export price. Domestic production and use can be controlled by local government but the other two factors cannot. International commodity trade is a complex phenomenon and depends on economic and noneconomic factors which differ with time and country. Hence, the trade model is built with provisions for solving under different assumptions.

The present simulation study has two objectives: (a) analize the rice economy and short-term prediction of variables of interest (b) provide a package program which can be used with small computers.

An intercountry model can be constructed in two somewhat different ways. Individual countries can be considered separately in estimating the structural equations of the model. A consistency or equilibrium condition is then used to link the country submodels to an aggregative world model. In a second approach, an aggregate world model can first be constructed, then broken down to individual country submodels. A statistically and economically acceptable model from the data available can be constructed with less difficulty with the second approach. The coefficients of the relevant variables are of the correct sign and are statistically significant at an aggregative macro level.

In explaining the model, we follow this order: (a) establishing assumptions involved in aggregating the countries, (b) specifying the model and estimation of the structural equations, (c) setting up the simulation experiment and results, (d) developing a stochastic simulation experiment for future prediction, (e) forecasting under different alternative assumptions, and (f) explaining the conclusions. The computer package program is presented in the appendix.

ASSUMPTIONS INVOLVED IN AGGREGATING THE COUNTRIES

The major rice producing and consuming countries are situated in Asia. Other countries produce and consume rice but to lesser extents. In the latter group the United States potentially is most influential in the world rice economy. We have divided the countries into two broad groups (a) net exporters, and (b) net importers of rice. Based on past data we have computed net trade of every country for the period of 1957 to 1975 [1]. Most of the countries fall clearly in either group.

fall clearly in either group. However, a few small countries are "crossovers" between the groups in some years. The net exporting countries are Thailand, United States, China, Burma, Egypt, Italy, Australia, Guyna, Nepal, Japan, Khmer Republic, Pakistan, Vietnam, Taiwan, and the Latin American countries (Argentina, Chili, Ecuador, Peru, Surinam, Uruguay, Venezuala). The net importing countries are India, Indonesia, South Korea, Bangladesh, Singapore, Malaysia, Sri Lanka, Laos, Hong Kong; African countries as a whole (Cameron, Gamlia, Ghana, Guinea, Ivory Coast, Liberia, Libya, Madagear); other European countries (Austria, Belgium, Finland, France, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom); Pacific Islands (Macao, Fraq, Iran, Isreal, Jordan, Lebannon, Saudi Arabia, Syria, Turkey); the Communist Block (Cuba, North Korea, North Vietnam, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Russia, Yugoslavia, and Rumania); Canada; and the rest of the Latin American Countries (Costa Rico, Dominican Republic, El Salvador, Honduras, Jamaica, Mexico, Nicaraga, Panama, Trinidad and Brazil). In some cases we have treated several countries as a group to check whether they should be used as importers or exporters. These countries are indicated in the parentheses following the identification of the broad group. We develop and simulate a rice trade model with respect to these two broad groups, exporters and importers.

MODEL SPECIFICATION AND ESTIMATION OF THE STRUCTURAL EQUATIONS

The model is based on the following structural equations:

$$(EPTH)_T = ALEPTH + BEPTH * (TNIMD)_{T-1} + GEPTH * T + U_1 \quad (1)$$

$$(PREC)_T = ALPREC + BEPREC * (TNIMD)_{T-1} + GPREC\ (PRIC)_T + U_2 \quad (2)$$

$$(TNIMD)_T = (TCIC)_T - (PRIC)_T \quad (3)$$

$$(TCIC)_T = ALTCIC + BETCIC * (POPIM)_T + U_3 \quad (4)$$

$$(PRIC)_T = ALPRIC + BEPRIC * (ARIM)_T + U_4 \quad (5)$$

$$(POPIM)_T = ALPOP + BEPOP * T + U_5 \quad (6)$$

$$(ARIM)_T = ALARIM + BEARIM * T + U_6 \quad (7)$$

$$(THCON)_T = (THPR)_T - (THEX)_T \quad (8)$$

$$(THCON)_T = ALTCON + BETCON * T + U_7 \quad (9)$$

$$(THPR)_T + ALTHPR + BETHPR * (PREC)_T + U_9 \quad (10)$$

where:

$(EPTH)_T$ = unit export price for Thailand in period T in constant 1963 dollars.

$(PREC)_T$ = total production of the exporting countries in period T (000 metric tons of paddy equivalent).

$(TNIMD)_T$ = total import demand by the importing countries in period T (000 metric tons of paddy equivalent).

$(PRIC)_T$ = total production of the importing countries in period T (000 metric tons of paddy equivalent).

T = time trend

ALEPTH, ALPREC, BEPTH, BEPREC, GEPTH, GPREC = parameters to be estimated.

$(TCIC)_T$ = total consumption of the importing countries in period T (000 metric tons of paddy equivalent).

$(POPIM)_T$ = total population of the importing countries in period T (000 million).

$(ARIM)_T$ = total area harvested in rice in the importing countries (000 the hectares).

ALTCIC, ALPRIC, BETCIC, BEPRIC, ALPOP, ALARIM, BEPOPO, BEARIM = parameters to be estimated.

$(THCON)_T$ = Thailand's consumption of rice in year T (000 metric tons of paddy equivalent).

$(THPR)_T$ = Thailand's production of rice in year T (000 metric tons of paddy equivalent).

ALTCON, ALTHR, BETCON, BETHPR = Parameters to be estimated.

U_1 to U_9 = error terms associated with the equations.

The last three equations, (8), (9), and (10), refer to Thailand. This subsystem of equations is connected with the main body of equations via $(PREC)_T$ in equation (10).

The economic interpretation of the equations is straightforward. The importers are assumed to produce rice according to their consumption need (equation 5). Consumption in the importing countries, in its turn, is assumed as a function of population (4). Population is calculated by a simple time trend (equation 6). Net import demand is computed by equation (3) as the difference of consumption and production. On the other hand, the production of the exporters is assumed to be in response to import demand in the previous year (equation 2). Referring to equation

(2), the third expression in the right hand side, GPREC * $(PRIC)_T$, reflects to some extent farmers' aggregate response in the importing countries to increasing demand and the fact that there is certain positive correlation in the effect of weather on the production of the two groups of countries. Thailand's export price is assumed to be a function of last year's import demand and a time trend (equation 1).

Consumption of rice in Thailand is determined as a function of time by equation (9). Thailand is a member of the exporting group and, accordingly, production of rice in Thailand is determined as a function of the total production of the exporting countries by equation (10). The coefficient (BETHPR) in equation (10) denotes the share increase of Thai rice production for each unit increase in total rice production of the exporting group. Thailand's trade is computed by equation (8) as the difference between production and consumption.

Equations (1) through (7) appear to be a simultaneous system. But it can be shown that the system of equations constitutes a simultaneous recursive system. The variables in the equations can be divided into two classes. Variables T, $(TNIMD)_{T-1}$ and a column of 1 (denoting intercept) are treated as exogenous or predetermined variables. The rest of the variables, $(POPIM)_T$, $(ARIM)_T$, $(TCIC)_T$, $(PREC)_T$, $(EPTH)_T$ and $(PRIC)_T$, are treated as endogenous variable. Equation (3), relating production, consumption and trade, is an identity. Moreover, the variable $(TNIMD)_T$ enters the system as predetermined lagged variable $(TNIMD)_{T-1}$. Thus, equation (3) is not considered at present to be a recursive property of the system. The system comprised of equations 1, 2, 4, 5, 6, and 7 can be written in matrix notation:

$$\underbrace{\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & -BETCIC & 0 & 1 & 0 & 0 \\ 0 & 0 & -BEPRIC & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & -GPREC & 1 \end{bmatrix} \begin{bmatrix} (EPTH)_T \\ (POPIM)_T \\ (ARIM)_T \\ (TCIC)_T \\ (PRIC)_T \\ (PREC)_T \end{bmatrix}}_{\text{endogenous}} + \underbrace{\begin{bmatrix} -ALEPTH & -BEPTH & -GEPTH \\ -ALPOP & -BEPOP & 0 \\ -ALARIM & -BEARIM & 0 \\ -ALTCIC & 0 & 0 \\ -ALPRIC & 0 & 0 \\ -ALPREC & 0 & -BEPREC \end{bmatrix} \begin{bmatrix} 1 \\ T \\ (TNIMD)_{T-1} \end{bmatrix}}_{\text{predetermined}} = \begin{bmatrix} U_1 \\ U_5 \\ U_6 \\ U_3 \\ U_4 \\ U_2 \end{bmatrix} \qquad (11)$$

Equation (11) indicates that the present system of equations forms a recursive system. The upper triangular matrix associated with the endogenous variable is zero. If we assume that the error terms across the equations are not correlated, the equations can be estimated by conventional ordinary least squares (OLS) [2]. The OLS technique is applied on the time series data to estimate all the equations, (1) through (10). Corrections have been made for first-order autocorrelation wherever necessary.

The main source of data is the Production Yearbook and the Trade Yearbook [1,3] of the Food and Agricultural Organization. The data for production of rice are given in paddy equivalent but the trade data are given in units of milled rice. Because the volume of trade is small compared to the volume of production, we have transformed the trade figures into equivalent paddy units for subsequent computation. When the results concerning trade are reported, they are transformed back to milled rice equivalent for comparison with the original data given in FAO yearbooks.

The transformation is done by using a milling rate from a published source [4]. It is well known that the export price of 5 percent broken Thai white rice, f.o.b. Bangkok is most widely quoted as the "world price", because Thailand is the largest exporter in the world market of rice on regular commercial terms. In the present study we use not the 5 percent broken rice price but the overall export price of rice for Thailand as the world price. The set of prices was computed from Trade Yearbook data of total value of trade divided by total quantity. We assume that this set of unit export prices of Thailand reflects the supply and demand situation of the world. Indices have been computed to transform the prices into 1963 constant price to suppress the effect of inflation [5].

The sample period is from 1956 to 1972. The years 1973, 1974, and 1975 are unusual years, marked by significant shortfalls in world production in 1972 and severe stock depletion throughout the world in subsequent years. As a result, prices rose sharply and the magnitude of trade fell well below the normal trend. These three years are excluded from our sample for the present time in estimating equations 1 and 2. For other equations, the whole data set is used for estimation.

The following are the estimated equations:

Estimate of equation (1)

$$(EPTH)_T = \underset{}{282.3492} - \underset{(t = -5.8)}{0.03183}\ (TNIMD)_{T-1} + \underset{(t = 2.0)}{2.46025T} \qquad (11)$$

Mean square error = 163.6

$R^2 = .81$

Estimate of equation (2)

$$(PREC)_T = 48569.0910 + \underset{(t\,=\,2.0)}{4.69911}(TNMID)_{T-1} + \underset{(5\,=\,5.0)}{0.82435}(PRIC)_T \qquad (12)$$

Mean square error = 45038249

R^2 = .75

Estimate of equation (4)

$$(TCIC)_T = -44599.54 + \underset{(t\,=\,8.7)}{96.06334}\ (POPIM)_T \qquad (13)$$

Mean square error = 36893670

R^2 = .89

Estimate of equation (5)

$$(PRIC)_T = -161224.72 + \underset{(t\,=\,9.3)}{4.29652}\ (ARIM)_T \qquad (14)$$

Mean square error = 26144946

R^2 = .85

Estimate of equation (6)

$$(POPIM)_T = 1348.86 + \underset{(t\,=\,20.2)}{31.9336}T \qquad (15)$$

Mean square error = 8.34

R^2 = .99

Estimate of equation (7)

$$(ARISM)_T = 56463.87 + \underset{(t\,=\,14.2)}{660.27573}T \qquad (16)$$

Mean square error = 1039970

R^2 = .93

Estimate of equation (9)

$$(THCON)_T = 769.61 + 62.11811T \quad (17)$$
$$(t = 5.6)$$

Mean square error = 1311944

R^2 = .69

Estimate of equation (10)

$$(THPR)_T = 72.26 + 0.07198\ (PREC)_T \quad (18)$$
$$(t = 6.2)$$

Mean square error = 951370

R^2 = .73

The R^2's of the estimated equations are high and the t's of the coefficients are highly significant. The structural equation thus might be used to formulate a model where each coefficient will have significant response on the overall system.

SETTING UP THE SIMULATION EXPERIMENT AND RESULTS

Equation (11) provides the foundation for designing a recursive simulation model. At present we assume that the error terms U_1 to U_9 are zero. Hence, the model is completely deterministic. The initial input in the system is the time period T. The rule of the simulation is as follows:

(a) determine $(POPIM)_T$ and $(ARIM)_T$ from equations (6) and (7).

(b) determine $(TCIC)_T$ and $(PRIC)_T$ from equations (4) and (5).

(c) determine $(TNIMD)_T$ from equation (3).

(d) determine $(PREC)_T$ and $(EPTH)_T$ from equations (2) and (1).

(e) determine $(THCON)_T$ and $(THPR)_T$ from equations (9) and (10).

(f) determine $(THEX)_T$ from equation (8).

Figure (1) diagramatically represent the simulation experiment

The input is only the time trend; the outputs are the total production of the importing countries in period T, consumption by the importing countries in period T, production of the exporting countries in period (T + 1), and the export price in period (T + 1). In this way we simulate the time paths of the variables concerned over any period. The assumption that time is the only relevant initial input variable is naive but we perform a base run on the model which then gives a trended time path. Random shocks can then be imposed in different steps of the simulation to produce fluctuation from the trend path. The magnitude of the shocks can either be assumed exogenous or can be determined by the performance of the individual structural equations over the sample period.

The performance of the simulation model can be easily tested by simulating the model over the sample period and comparing it with actual data. We have simulated the trade model over the years 1962 to 1972. The actual FORTRAN program is given in the appendix. Tables 1, 2, and 3 show the simulated and actual values of the variables under consideration. It should be noted that the export figures are in milled rice units whereas the other rice quantities are shown in units of paddy equivalent. The price is given in \$/metric ton of milled rice. Tables 1, 2, and 3 show that the present model tracks fairly well over the sample period under consideration.

Table 1. Simulation of total consumption of the importing countries $(TCIC)_T$, production of the importing countries $(PRIC)_T$ and total net import demand $(TNIMD)_T$.

Year	(TCIC)T(000 M. Ton) Simulated	(TCIC)T(000 M. Ton) Actual	(PRIC)T(000 M. Ton) Simulated	(PRIC)T(000 M. Ton) Actual	(TNIMD)T(000 M. Ton) Simulated	(TNIMD)T(000 M. Ton) Actual
1962	103382.	101798.	98395.	96261.	4756.	5587.
1963	106449.	110438.	101232.	104559.	4987.	5879.
1964	109517.	115571.	104068.	109381.	5217.	6190.
1965	112585.	102163.	106905.	96815.	5448.	5348.
1966	115652.	102331.	109742.	96799.	5679.	5532.
1967	118720.	115794.	112579.	110682.	5910.	5112.
1968	121788.	120466.	115416.	115136.	6140.	5380.
1969	124855.	127083.	118253.	120145.	6371.	6983.
1970	127923.	133375.	121090.	125835.	6602.	7540.
1971	130991.	133055.	123927.	118127.	6833.	7866.
1972	130458.	125428.	126763.	132516.	7063.	7301.

Table 2. Simulation of export price $(EPTH)_T$ and total production of the exporting countries $(PREC)_T$

Year	(EPTH)T($/M. Ton in 1963 constant price) Simulated	(EPTH)T($/M. Ton in 1963 constant price) Actual	(PREC)T(000 M. Ton) Simulated	(PREC)T(000 M. Ton) Actual
1962	146.	130.	152031.	144789.
1963	141.	107.	155454.	148755.
1964	136.	101.	158877.	159534.
1965	131.	106.	162300.	159677.
1966	126.	121.	165723.	165354.
1967	121.	145.	169146.	173643.
1968	116.	156.	172568.	172610.
1969	112.	131.	175992.	174797.
1970	106.	102.	1794.4.	186003.
1971	102.	75.	182838.	188836.
1972	96.	76.	186260.	183015.

Table 3. Simulation of Thailand's production $(THPR)_T$ and export $(THEX)_T$

Year	(THPR)T(000 M. Ton) Simulated	Actual	(THEX)T(000 M. Ton) Simulated	Actual
1962	11015.	10150.	1960.	1537.
1963	11261.	11250.	1858.	1271.
1964	11508.	12171.	1756.	1417.
1965	11754.	11600.	1654.	1896.
1966	12001.	11164.	1552.	1895.
1967	12247.	13500.	1450.	1507.
1968	12493.	11198.	1348.	1482.
1969	12740.	12410.	1246.	1077.
1970	12986.	13410.	1144.	1023.
1971	13233.	13270.	1042.	1591.
1972	13479.	12413.	939.	2112.

The fluctuation around trend which occurs in the observed values of the variables can be treated in the present system by incorporating stochastic characteristics in all or some of the structural equations (1) through (10). In the next section, a stochastic simulation model is designed and is used for future prediction of trade and export prices.

SETTING UP A STOCHASTIC SIMULATION EXPERIMENT FOR FUTURE PREDICTION

In a stochastic version of the simulation experiment we assume that the error terms U_1 through U_7 associated with the structural equations (1) through (10) are not zero. By using OLS we have already made the implicit assumption that the errors U_1 through U_7 are normally distributed with zero mean and uniform variance σ^2. For a particular equation the estimated value of mean square error (MSE) gives the unbiased estimate of σ^2. Given the estimate of σ^2 we then can generate a random number (which corresponds to the relevant error term) from a normal population of zero mean and variance σ^2 by Monte Carlo sampling techniques.

The random number added to the R.H.S. of the particular estimated equations (11) through (18) makes the L.H.S. variable stochastic. We can repeat the sampling process for a reasonable number of times. Three times the size of the sample of which the regression equations have been estimated can be taken as the minimum sample size for such a Monte Carlo sampling experiment. Out of the hundred simulated values of the stochastic variable we than can compute a mean, a maximum and a minimum value. The error terms (U_1 through U_7) also have meaningful economic interpretations. The error term U_1 is associated with the export price equation (equation 1). Export price in any period depends on supply in that period. Supply is determined by the production decision of the exporting countries which, in turn, depend on previous years of import demand. But, good or bad weather is responsible for the difference in expected and realized production. This difference is responsible for the fluctuation of the export price over trend level. The error term U_1 contains the effect of weather variability together with the statistical discrepancy (misspecification of the model).

For future prediction it is of interest to have an idea of the variability expected, along with the mean value, for a variable of interest. For this purpose we use a stochastic version of the model. We have made

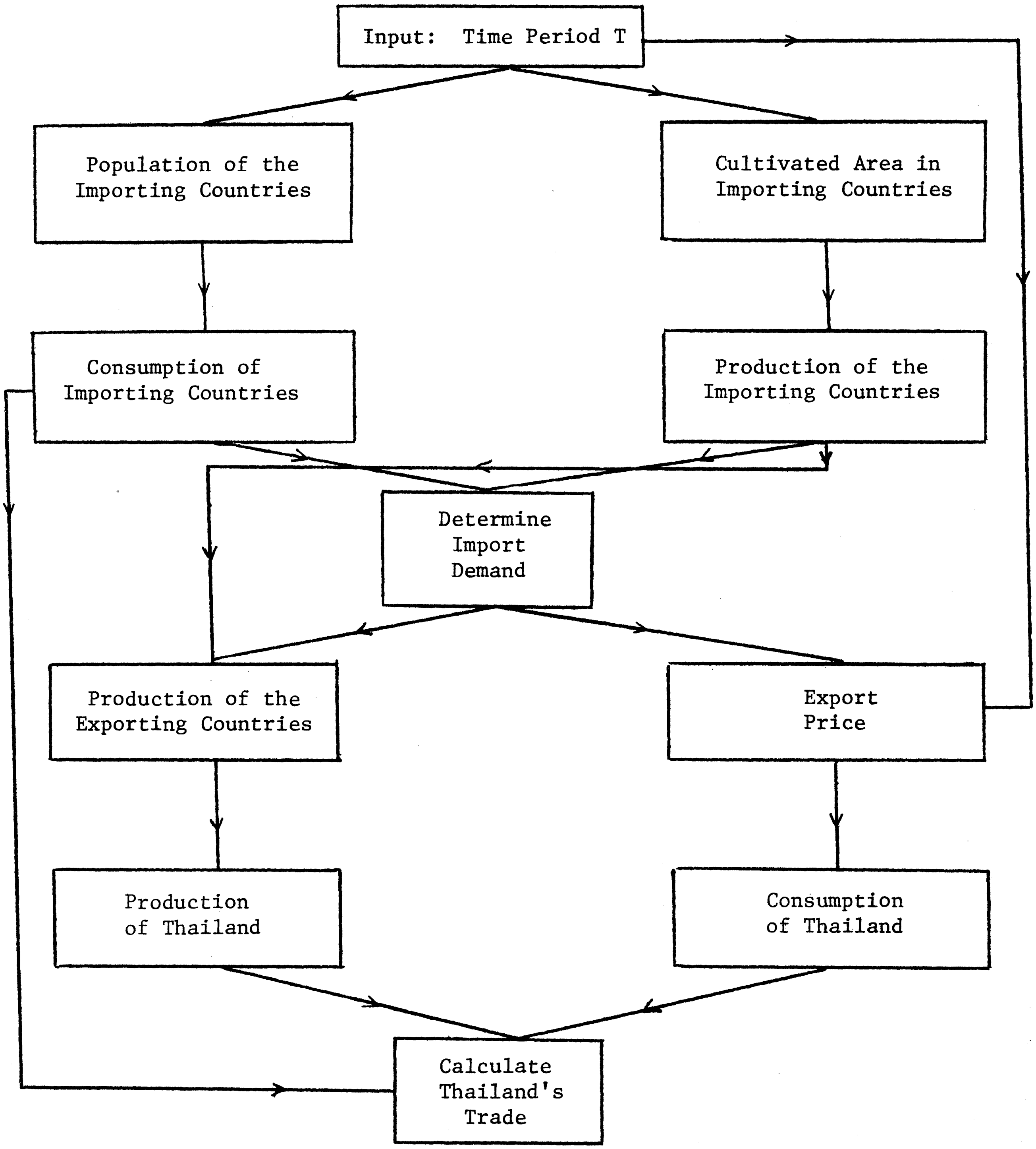

Figure 1. Flow chart of the simulation.

three variables, $(EPTH)_T$ in equation (1), $(PREC)_T$ in equation (2) and $(THCON)_T$ in equation (19), stochastic. We have simulated each error term, U_1, U_2, and U_9, one hundred times for each year. Then we have solved the whole simulation model (Figure 1) a hundred times for each year--once for one set of generated values of U_1, U_2, and U_3. For each stochastic variable we report the mean value, the minimum value, and the maximum value. The mean value of the variable corresponds to the result of nonstochastic simulation.

By using the simple model we have first attempted to predict values of different variables from 1979 to 1985. The input in the simulation model is again the appropriate value of T. In the present experiment the stochastic variables are export price $(EPTH)_T$, production of the exporting countries $(PREC)_T$, Thailand's production $(THPR)_T$ and Thailand's export $(THEX)_T$. Tables 4, 5, and 6 show the result of the stochastic simulation.

Table 4. Simulation of total consumption of the importing countries $(TCIC)_T$ production of the importing countries $(PRIC)_T$ and total net import demand $(TNIMD)_T$

Year	(TCIC)T(000 M. Ton)	(PRIC)T($/M. Ton) in 1963	(TNIMD)T(000 M. Ton
1979	155532.	146621.	8910.
1980	158599.	149458.	9141.
1981	161166.	152295.	9372.
1982	164735.	155132.	9602.
1983	167802.	157969.	9833.
1984	170870.	160806.	10064.
1985	173938.	163642.	10295.

It has been pointed out earlier that using a downward sloping linear function for price calculation might pose problems for long-term prediction. This situation occurred in computing the minimum export price (Table 5). The international trade in any commodity depends on both economic and noneconomic institutional factors. Government programs of subsidy, tariff, substitution of commodities and self-sufficiency are a few among the various economic-institutional factors. Political decisions in trade negotiations are the main noneconomic factor. These factors will affect the slope of the simple linear functions assumed in the present study. To illustrate this situation, we have reestimated equation (11) denoting export price as a function of the previous year's import demand and time trend considering only the last eight years of data (from 1966 to 1972) from the original sample

Table 5. Stochastic simulation of export price $(EPTH)_T$ and production of the exporting countries $(PREC)_T$

	(EPTH)T($/M. Ton) in 1983[a]			(PREC)T(000 M. Ton)		
Year	Mean	Minimum	Maximum	Mean	Minimum	Maximum
1979	60.37	33.38	83.61	208033.	193403.	220580.
1980	55.11	30.59	85.77	210935.	198309.	230255.
1981	50.85	18.50	77.47	214340.	195587.	232266.
1982	44.75	12.55	80.18	217587.	203431.	232477.
1983	42.13	-	67.32	221096.	206992.	234864.
1984	36.97	-	73.95	224479.	209837.	245823.
1985	31.38	-	61.19	228489.	209812.	244980.

[a] Minimum price of 1983, 1984 and 1985 are very low and not reflected.

Table 6. Stochastic simulation of Thailand's production $(THPR)_T$ and Thailand's export $(THEX)_T$

	(THPR)T(000 M. Ton)			(THEX)T(000 M. Ton)		
Year	Mean	Minimum	Maximum	Mean	Minimum	Maximum
1979	15046.	13993.	15949.	22.	-3205.	3328.
1980	15255.	14346.	16646.	-108.	-4293.	4694.
1981	15500.	14150.	16790.	-133.	-3609.	4511.
1982	15734.	14715.	16805.	-164.	-3666.	3652.
1983	15986.	14971.	16977.	-603.	-4413.	3320.
1984	16230.	15176.	17766.	-655.	-4578.	3413.
1985	16518.	15174.	17705.	-670.	-4588.	3294.

period of 1962 to 1972. The following is the reestimated equation. Figures in the parentheses represent the old estimate of the coefficient.

$$(EPTH)_T = \underset{(282.3492)}{273.83043} - \underset{(.03183)}{0.03281}\ (TNIMD)_{T-1} + \underset{(2.46025)}{3.56043}T \tag{19}$$

Based on equation (19), we have recomputed the simulated price for the period 1979 to 1985. Table 7 shows the result of the simulation. The computed prices are much higher than in Table 5.

Table 7. Stochastic simulation of export price $(EPTH)_T$ using equation (19)

	(EPTH)T($/M. Ton)[1]		
Year	Mean	Minimum	Maximum
1979	67.55	40.56	90.79
1980	63.17	38.64	93.82
1981	59.78	27.42	86.39
1982	54.55	22.35	89.38
1983	52.81	12.37	77.99
1984	48.52	20.40	85.50
1985	39.79	-	69.60

[1]Minimum price of 1985 turns out to be very low and not reported.

The above illustration points out an obvious limitation of using a linear model for forecasting. Such a model can be effectively used only for short-time forecasting of two to five years. Moreover, the structural parameters should be reestimated periodically by adding new observation points and deleting some of the old ones to caputure the current effect of institutional factors.

FORECASTING UNDER DIFFERENT ALTERNATIVE ASSUMPTIONS

It was pointed out earlier that the present study is performed with special reference to Thailand. Although different policy runs can be performed for the world as a whole, presently we report some of the policy runs specific to Thailand. One of the two objectives of this study is to develop a readily workable package program of rice trading which can be used by government officials to get a quantitative idea concerning outcomes of alternative policies. The policy runs which are presented in this section should be treated as illustrative examples rather than an attempt to suggest specific policies.

A previous study of world rice markets [6] concludes: "Relative insensitivity of world price to changes in Thailand's export tax rates on rice indicates an almost perfect case of small county position of Thailand in the international rice markets. Thailand is practically a "price-taker" in the world market. Even though Thailand accounts for 15-25 percent of total rice exports, its output is less than 5 percent of world output." The same study also notes, "simulation results ... indicate clearly that the world demand for rice must be relatively inelastic. It can be seen that a 10 percent increase in the world price will result in about 1 percent reduction in total world demand for rice." Alternatively, a slight change in world demand can cause considerable fluctuation in world equilibrium export price.

The above two findings, that Thailand is a price-taker in the world market and the fact that world demand is relatively inelastic, plays a major role in designing the present illustrative policy runs. It was concluded in the last section that this model can be best applied for a short-term forecasting of 2 to 5 years. In the short-term we do not expect much fluctuation in the world import demand. Accordingly, the world export price should be near its trend level. Price might fluctuate do to a production shortfall or production excess as results of bad or good weather. If drastic weather change does take place, the price still should be within the range specified in Table (5). In the present assumptions of the model the policy option left to Thailand is to increase her own exports. This can be done in three ways; (a) by increasing domestic production, (b) by decreasing domestic consumption, and (c) both. In all cases the export revenue can be computed in this model. Referring back to Tables (2) and (3), the total simulated world production of rice and Thailand's production of rice have a slightly increasing trend over time, whereas simulated Thai exports has a decreased trend. The observed quantities of Thai exports, however, appear to have an increasing trend with considerable fluctuation. This result is because of overestimation, by equation (17), of Thailand's consumption needs. This bias is so prominent that in projections for the future (Table 6) the mean export figures become negative after 1979.

In the present model Thai consumption is calculated as a function of time by equation (17). The coefficient associated with time trend (T) can be decreased to reflect various levels of reduction in consumption. A consumption cut in rice will mean an equivalent substitution for rice by other cereal crop.

The other alternative for increasing the export level is to increase Thailand's share of production in equation (18) by updating the relevant coefficient. Thailand's total rice production increases and so do the exports. The increased production calls for added land under rice cultivation. Feasibility of bringing added land area is also analyzed.

The third alternative is to consider both increases in production and decreases in consumption need. This policy produces the largest export increase. It can be reflected by changing the coefficients in both equations (17) and (18) in the simulation model.

Table 8 summarizes the results of three alternative policies; (A) a 10 percent decrease of consumption in Thai exports, (B) a 10 percent increase in rice production, and (C) 10 percent increase in production together with a 10 percent decrease in consumption. Henceforth, the three policies will be referred to as policy A, policy B, and policy C. Export prices are computed under the two different coefficient sets (Column 1 of Table 5, calculated with the old set, will be referred to as set 1 and column 2 of Table 7 calculated with the new set which will be referred to as set 2) also are given in Table 8. Table 9 shows the mean export earnings as a result of Thai export increase under three alternative policies, A, B, and C, with two different mean price sets.

Table 8. Simulation of effect of (a) 10 percent cut in consumption coefficient (b) 10 percent increase in share of production (c) 10 percent decrease in consumption coefficient together with 10 percent increase in share of production on Thai export $(THTR)_T$.

Year	Base Run (no policy) export (000 M. Ton)			10% cut in consumption coefficients export (000 M. Ton)			10% increase in share of production export (000 M. Ton)			10% cut in consumption coeff. and 10% increase in prodn. coeff. export (000 M. Ton)			Mean export price (first set) ($/M. Ton) 1963 = 00	Mean export price (second set) ($/M. Ton) 1963 = 00
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum		
1979	22	-3205	3328	908	-2893	5520	1461	-1867	4855	2344	-1556	7088	60.18	67.36
1980	-108	-4293	4694	545	-3994	4882	1351	-2920	6287	2002	-2667	6463	55.13	63.18
1981	-133	-3609	4511	702	-3023	5422	1349	-2255	6118	2183	-1644	7050	51.76	60.68
1982	-164	-3666	3652	575	-4128	4823	1341	-2259	5261	2084	-2749	6445	45.97	55.77
1983	-603	-4413	3320	608	-3390	5013	926	-2980	4945	2142	-1975	6658	41.11	51.78
1984	-655	-4573	3413	368	-4257	4209	548	-3474	4766	1722	-2839	5876	35.23	46.77
1985	-670	-4588	3294	690	-4255	5823	1180	-2866	5260	2292	-2807	7551	27.93	41.22

Table 9. Simulated mean export earnings (million $ in 1963 price) from three alternative policies

Year	Export Revenue With Policy a		Export Revenue With Policy b		Export Earning With Policy c	
	first set of mean export price	second set of mean export price	first set of mean export price	second set of mean export price	first set of mean export price	second set of mean export price
1979	54.5	60.8	87.9	98.4	141.0	157.8
1980	30.0	34.4	74.5	85.3	110.4	126.5
1981	36.3	42.6	69.8	81.9	113.0	132.3
1982	26.4	32.1	61.6	74.8	95.8	116.2
1983	24.9	31.5	38.1	48.0	88.1	110.9
1984	13.0	26.2	19.3	25.6	62.4	80.5
1985	19.3	28.5	32.9	48.6	64.0	94.5

Referring to Tables 8 and 9, the largest amount of exports and thus the largest amount of export revenue is achieved by policy C which simultaneously reduces consumption and increases production.

In policy A (decreasing consumption), the production figures remain unchanged. But in the other policies, the production has to increase and added land is brought under rice cultivation. The amount of land necessary to sustain the required level of production can be computed easily by dividing the production figure by average yield figure. Table 10 summarized the results of simulated mean production and required mean land area under rice cultivation under policy alternative B. Production under policy C will be the same as that under B.

Table 10. Simulated mean production and required land area under rice cultivation in Thailand

Year	No Policy		Policy B or C	
	Mean Production (000 M. Tons)	Mean Land Area (000 Hectares)	Mean Production (000 M. Tons)	Mean Land Area (000 Hectares)
1979	15046.	7998.	16486.	8746.
1980	15225.	8110.	16715.	8886.
1981	15500.	8240.	16983.	9028.
1982	15734.	8365.	17239.	9164.
1983	15986.	8499.	17516.	9312.
1984	16230.	8628.	17783.	9454.
1985	16518.	8781.	18370.	9766.

The increased land requirement for rice cultivation under policy B is obvious. Corresponding to each year under policy B, 9 percent more land under rice cultivation is required to sustain the increased production target. The land requirement for rice cultivation under policy C is the same as policy B.

By trial and error methods, an optimum level of consumption decrease and production increase can be computed which will satisfy the target level of export earning.

CONCLUSION

International trade is a complex and sometimes quite unpredictable phenomena. It can be argued that economic models of foreign trade may be rendered useless by political factors. But, an economic model is valid if it reflects fairly accurately the pattern of trade and prices that would result from given initial conditions in the absence of further policy changes. Such a model at least reflects the economic pressures that are imposed upon exporters and importers in different countries. The governments of these countries may undertake actions to offset such pressures.

The simple simulation model developed in this report explains past behavior of the relevant variable fairly well. The structure of the model is essentially linear but we show how periodic reestimation of the linear parameters provide a realistic measure of response to different economic phenomenon.

The model used in this study is aggregative. We divide the world into two major groups, exporters and importers. It is assumed that the importers have limited resource for domestic production and they must import to satisfy their consumption demand. The exporting group has excess production capacity over its consumption need. Thus, the export group can make production decisions on the basic supplies available for export and prices. Price fluctuations occur mainly due to differences in expected and realized production. The effect of production fluctuation on price is simulated via the response of lagged demand on price. We cannot control the effect of production fluctuation on price but can generate an upper bound and a lower bound on expected price which gives a quantitative idea about the price fluctuation.

It has been assumed that Thailand is a price-taker in the world rice market. Thailand is considered as a member of the exporting group and production is computed as a function of the total production of the exporting group. Thai rice trade has been computed as the difference between of production and domestic consumption. Although Thailand is one of the major rice exporting countries, rice is also the main staple food there. Thus, we have two, clear, policy options for increasing rice exports. Either consumption can be decreased or production can be increased, or both. These two policy alternatives have been analyzed in this study.

In the present aggregative model, lagged import demand plays the major role in simulating the behavior of prices and exports. Demand for stocks in not treated separately in the model. A stock submodel should be included to make it more realistic. Demand for stocks mainly depends on government decisions and causes fluctuation from the expected trend of import demand.

The simulation study is not complete since improvement can be made in several of its aspects. The basic computer program, presented in the appendix, can be altered to suit the specific needs of policy planners.

REFERENCES

1. Food and Agricultural Organization of the United Nations. Trade Yearbook, 1975. Rome.
2. Johnston, J. Econometric Methods. McGraw Hill, Second Edition.
3. Food and Agricultural Organization of the United Nations. Production Yearbook, 1975. Rome.
4. Food and Agricultural Organization of the United Nations. FAO Rice Report 1974/1975. Rome.
5. United Nations. Monthly Bulletin of Statistics, November, 1975. Vol. XXIX, No. 11.
6. Department of Economic Research, Bank of Thailand. An Econometric Model of World Rice Markets. Bangkok, Thailand.

APPENDIX

The FORTRAN program used for the stochastic simulation

The main FORTRAN program uses two subroutine. The first is GAUSS which is a standard I.B.M. subroutine and can be found in the manual entitled Scientific Subroutine Package System (SSPS). Subroutine GAUSS is used to generate random numbers from a specified population. The second subroutine is VMEA which was developed by the author. Subroutine VMEA is used to determine the mean, maximum, and minimum in a set of numbers.

We first present the main program, then explain the input variables and output variables.

Input variables of the program:

N = number of years for which the model is to be simulated.

NSIM = number of times the model is to be simulated for each year or how many random numbers are generated for each year. In the present example it is 100.

T(I) = a vector of time trend. The starting year of the simulation (1962 in the present example) is coded as 1, i.e. T(1) = 1, next year i.e. T(2) = 2 and so on.

ALAR, BEAR = associated parameters of the area equation corresponds to ALARIM and BEARIM of equation (7) in the text.

ALPOP, BEPOP = associated parameters of the population equation. Corresponds to ALPOP and BEPOP of equation (6) in the text.

ALTCI, BETCI = parameters of the total consumption equation. Correspond to ALTCIC and BETCIC of equation (4).

ALTPI, BETPI = parameter of the total production equation. Corresponds to ALPRIC and BEPRIC of equation (5).

ALEPR, BEPR, GEPR = parameters associated with the production equation. Corresponds to ALPREC, BEPREC, GEPREC of equation (2).

ALPC, BEPC, GEPC = parameters of the price equation. Correspond to ALEPTH, BEPTH and GEPTH of equation (1).

ALPI, BEPT = parameters of the production equation for Thailand. Correspond to ALTHPR, BETHPR of equation (10).

ALCOT, BECOT = parameter of the consumption equation for Thailand. Correspond to ALTCON and BETCON of equation (9).

Output variable:

AR(I): land area under cultivation in the importing countries in the ith year

POP(I): population of the importing countries in the ith year

TCONS(I): consumption demand in the importing countries in the ith year

TPR(I): production in the importing countries in the ith year

TDEM(I): in the ith year.

TEXP1(I), TEXP2(I), TEXP3(I): Minimum export price, mean export price and maximum export pirce in the ith year

TPRIC1(I), TPRIC2(I), TPRIC3(I): Minimum production, mean production and maximum production of the exporting countries in the ith year

TCONS1(I), TCONS2(I), TCONS3(I): Minimum consumption, mean consumption and maximum consumption of Thiland in the ith year

THPR1(I), THPR2(I), THPR3(I): Minimum production, mean production and maximum production of Thailand in the ith year

THTR1(I), THTR2(I), THTR3(I), Minimum, mean and maximum export of Thailand

It is to be noted that in this stochastic simulation model only three equations (equations 11, 13 and 17) are considered to be stochastic. We can make the other equations stochastic by making minor additions in the program.

Now we discuss the subroutine VMEA. The FORTRAN program is as follows:

```
      SUBROUTINE VMEA (S, NSIM, AMAX, AMIN, AMEAN)
      DIMENSION S (100)
      X = 0.
      DO 3 I = 1, NSIM
  3   X = X + S (I)
      AMEAN = X/NSIM
      AMAX = S (1)
      DO 5 I = 1, NSIM
      IF (S (I) - AMAX) 5, 5, 6
  6   AMAX = S (I)
  5   CONTINUE
      AMIN = S(1)
      DO 50 I = 1, NSIM
      IF (S (I) - AM IN) 60, 50, 50
 60   AMIN = S (I)
 50   CONTINUE
      RETURN
      END
```

S: A vector is set of numbers whose mean, maximum and minimum is to be determined.

NSIM: the sample size is number of times the random numbers are generated for each year

AMAX: the maximum number in the set s

AMIN: the minimum number in the set s

AMEAN: the mean of the set s.

The calling sequence of subroutine GAUSS is as follows

CALL GAUSS (IX, S, AM, V)

where IX: any two digit integer number.

S: specified standard deviation of the population

AM: mean of the population

V: the generated random number.

```
$JOB          U4219MOHIREN,TIME=30,PAGES=50
         DIMENSION POP(20),TR(20),AR(20),SEXPR(200),SPRIC(200),
        1TEXP1(20),TEXP2(20),TEXP3(20),TPRIC1(20),TPRIC2(20),TPRIC3(2
        1THCON(20),THPR1(20),TDEM(20),TPR(20),TH1(200),TCONS1(20),
        1THPR2(20),THPR3(20),THTR1(20),THTR2(20),THTR3(20),TCONS(20),
         DIMENSION TCONS2(20),TCONS3(20)
         READ(5,10)N,NSIM
10       FORMAT(2I3)
         READ(5,1)(T(I),I=1,N)
1        FORMAT(8F10.0)
         READ(5,2)ALAR,BEAR,ALPOP,BEPOP
         READ(5,2)ALTCI,BETCI,ALTPI,BETPI
         READ(5,2)ALEPR,BEPR,GEPR,ALPC,BEPC,GEPC
         READ(5,2)ALPT,BEPT,ALCOT,BECOT
2        FORMAT(6F10.0)
         DO 30 I=1,N
         AR(I)=ALAR+BEAR*T(I)
         POP(I)=ALPOP+BEPOP*T(I)
         TPR(I)=ALTPI+BETPI*AR(I)
         TCONS(I)=ALTCI+BETCI*POP(I)
30       TDEM(I)=TCONS(I)-TPR(I)
         N1=N-1
         IX=3333
         AM=0.
         DO 11 I=1,N1
         J=I+1
         DO 500 K=1,NSIM
         S=6711.
         CALL GAUSS(IX,S,AM,V)
         H1=ALEPR+BEPR*TDEM(I)+GEPR*TPR(I)+V
         S=12.76
         CALL GAUSS(IX,S,AM,V)
         H2=ALPC+BEPC*TDEM(I)+GEPC*T(I)+V
         SEXPR(K)=H1
500      SPRIC(K)=H2
         CALL VMEA(SEXPR,NSIM,AMAX,AMIN,AMEAN)
         TEXP3(J)=AMAX
         TEXP1(J)=AMIN
         TEXP2(J)=AMEAN
         CALL VMEA(SPRIC,NSIM,AMAX,AMIN,AMEAN)
         TPRIC3(J)=AMAX
         TPRIC1(J)=AMIN
11       TPRIC2(J)=AMEAN
         DO 612 I=2,N
612      WRITE(6,401) AR(I),POP(I),TCONS(I),TPR(I),TDEM(I)
         WRITE(6,600)
600      FORMAT(' RESULTS')
         DO 62 I=2,N
62       WRITE(6,401) TEXP1(I),TEXP2(I),TEXP3(I),TPRIC1(I),TPRIC2(I),
        1TPRIC3(I)
401      FORMAT('0',8F15.2)
         DO 39 I=2,N
         THPR1(I)=ALPT+BEPT*TEXP1(I)
         THPR2(I)=ALPT+BEPT*TEXP2(I)
39       THPR3(I)=ALPT+BEPT*TEXP3(I)
         DO 40 I=2,N
         DO 41 K=1,NSIM
         S=1145.
         CALL GAUSS(IX,S,AM,V)
41       TH1(K)=ALCOT+BECOT*T(I)+V
```

```
      CALL VMEA(TH1,NSIM,AMAX,AMIN,AMEAN)
      TCONS3(I)=AMAX
      TCONS1(I)=AMIN
   40 TCONS2(I)=AMEAN
      DO 66 I=2,N
      THTR1(I)=THPR1(I)-TCONS3(I)
      THTR2(I)=THPR2(I)-TCONS2(I)
   66 THTR3(I)=THPR3(I)-TCONS1(I)
      WRITE(6,600)
      DO 67 I=2,N
   67 WRITE(6,401)TCONS1(I),TCONS2(I),TCONS3(I),THPR1(I),THPR2(I),
     1THPR3(I)
      WRITE(6,500)
      DO 68 I=2,N
   68 WRITE(6,401)THTR1(I),THTR2(I),THTR3(I)
      STOP
      END
```